**1.2.3.AK Binary Numbers and Conversion**

Introduction

Have you ever wondered why we use the base-ten, or decimal, number system? Of course, we have ten fingers. However, the decimal number system that works so well for us is completely incompatible with digital electronics. Digital electronics only understand two states, ON and OFF. This is why digital electronics use the base-two, or binary, number system. In order for you to be able to design digital electronics, you will need to be proficient at converting numbers between the decimal and binary number systems.

In this activity you will learn how to convert numbers between the decimal and binary number systems.

Equipment

Calculator (preferably one with a number base conversion feature)

Procedure

1. Complete the following decimal-to-binary number conversions. An example problem is shown below. If available, use the base conversion feature of your calculator to check your answers.

Example:

 19 (10) = \_\_?\_\_ (2)

Solution:

Answer: 19 (10)  = 10011 (2)

|  |  |
| --- | --- |
| 1. 17 (10)
2. 34 (10)
3. 58 (10)
4. 92 (10)
5. 119 (10)
6. 178 (10)
7. 297 (10)
8. 413 (10)
 | = **10001** (2)= **100010** (2)= **111010** (2)= **1011100** (2)= **1110111** (2)= **10110010** (2)= **100101001** (2)= **110011101** (2) |
| 1. Complete the following binary-to-decimal number conversions. An example problem is shown below. If available, use the base conversion feature of your calculator to check your answers.

Example: 101001 (2) = \_\_?\_\_ (10)Solution:Answer: 101001 (2) = 41 (10)

|  |  |
| --- | --- |
| 1. 1100 (2)
2. 11010 (2)
3. 111001 (2)
4. 1010011 (2)
5. 10000101 (2)
6. 10011001 (2)
7. 100100001 (2)
8. 111101010 (2)
 | = **12** (10)= **26** (10)= **57** (10)= **83** (10)= **133**  (10)= **153** (10)= **289** (10))= **490** (10) |

  |
| 1. Perform the remaining decimal-to-binary conversions to complete the table shown below.

|  |  |
| --- | --- |
| Decimal Number | Binary Number |
| MSB |  | LSB |
| 0 = | 0 | 0 | 0 |
| 1 = | **0** | **0** | **1** |
| 2 = | **0** | **1** | **0** |
| 3 = | **0** | **1** | **1** |
| 4 = | **1** | **0** | **0** |
| 5 = | 1 | 0 | 1 |
| 6 = | **1** | **1** | **0** |
| 7 = | **1** | **1** | **1** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Conclusion1. The decimal number system has served humans well since the beginning of mankind. Ug the caveman didn’t call it the decimal number system, but he undoubtedly used his fingers to count objects in his world. If the decimal system is so good, why do computer and other digital electronic devices use the binary number system?

**Transistors only have 2 states requiring base 2 mathematics**.1. Now that we are using a number system other than the decimal, it is important to properly subscript our numbers (i.e., 3510, 23410, 100102, etc.). Why is this so important? Provide at least three examples where neglecting to subscript numbers could lead to confusion.

**Students should recognize the same number can be represented by different values depending on the subscript.****Example 1616 = 2210 = 101102**1. Without performing the binary-to-decimal conversions, which of the following two binary numbers is the larger number :
	* 101101 (2) **= 4510**
	* 011010 (2) **= 2610**
2. How were you able to determine this? **It has a 1 in the MSB placeholder**
3. Perform the binary-to-decimal conversions and check your answer. Were you correct?
4. Examine the table that you completed in the procedure portion of the activity. What do you notice about the LSB (least-significant-bit)? What do you notice about the middle bit? What do you notice about the MSB (most-significant-bit)? Do you observe a pattern here?

**Student should see the alternating pattern (0,1,0,1,0,1,0,1)** **(00,11,00,11) (0000,1111)** **(00000000)**1. Based on your observations above, complete the table shown below.

|  |  |
| --- | --- |
| DecimalNumber | Binary Number |
| MSB |  |  | LSB |
| 0 = | 0 | 0 | 0 | 0 |
| 1 = | 0 | 0 | 0 | 1 |
| 2 = | 0 | 0 | 1 | 0 |
| 3 = | 0 | 0 | 1 | 1 |
| 4 = | 0 | 1 | 0 | 0 |
| 5 = | 0 | 1 | 0 | 1 |
| 6 = | 0 | 1 | 1 | 0 |
| 7 = | 0 | 1 | 1 | 1 |
| 8 = | **1** | **0** | **0** | **0** |
| 9 = | **1** | **0** | **0** | **1** |
| 10 = | **1** | **0** | **1** | **0** |
| 11 = | **1** | **0** | **1** | **1** |
| 12 = | **1** | **1** | **0** | **0** |
| 13 = | **1** | **1** | **0** | **1** |
| 14 = | **1** | **1** | **1** | **0** |
| 15 = | **1** | **1** | **1** | **1** |

**Going Further – Optional**1. What number system do you think the space alien character below would use? (Hint: count the fingers). **Alien = Base 6**

  Space Alien1. For some reason, most cartoon characters have traditionally been drawn with four fingers on each hand. What number system do you think these cartoon characters would use? **Cartoon = Base 8**

  Cartoon Characters1. Use your conclusions above to complete the following conversion table.

|  |  |  |  |
| --- | --- | --- | --- |
| DecimalNumber | BinaryNumber | Space Alien Number | Cartoon CharacterNumber |
| 35 | **1000112** | **438** | **556** |
| **2210** | 10110 | **268** | **346** |

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